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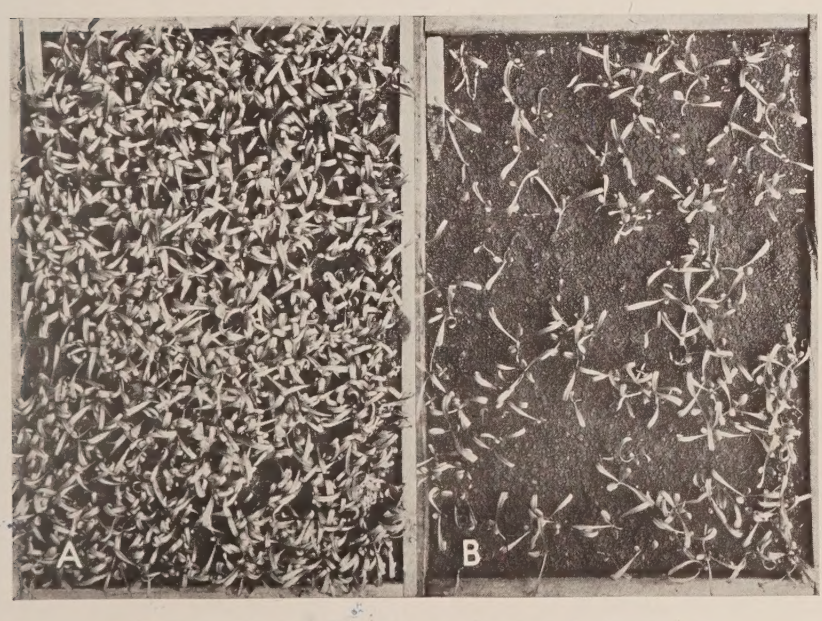

PASTEURIZING SOIL ELECTRICALLY CONTROLS DAMPING-OFF.
A, Pasteurized; B, Not pasteurized.

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ABSTRACT

The pasteurization of greenhouse soil with electric heat has given satisfactory control of damping-off caused mainly by *Pythium ultimum* Trow and to a lesser extent by *Rhizoctonia solani* and *Botrytis* sp. Most weed seeds, except clover and an occasional purslane seed, as well as nematodes and insects are killed likewise.

The chief advantage of the electric pasteurizer is that soil may be heated to a relatively low temperature (between 45° and 50°C) and then allowed to cook for 12 hours or more without additional heat. This saves expense and does not injure the soil as steaming does.

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PASTEURIZING SOIL ELECTRICALLY TO CONTROL DAMPING-OFF

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INTRODUCTION

The greenhouse industry of market gardeners and florists assumes considerable importance near the cities in New York State. Since every square foot of soil under glass is kept in production only at considerable effort and cost during the winter in this climate, it is imperative to maintain close control of the limiting factors. Damping-off is perhaps the chief limiting factor, at least in the production of seedlings, but as yet available control methods do not match the need for them.

Several lines of approach to the ultimate control of damping-off have been followed at this Station since 1929. Progress using relatively insoluble chemicals has been summarized recently in Bulletin No. 650 of this Station.[1] Another line of research here has been to pasteurize soil with electric heat.

DEVELOPMENT OF THE ELECTRIC PASTEURIZER

Following a consultation in the spring of 1931 between this Station, representatives of the electric power industry, and a manufacturer, a machine was built for "sterilizing" soil[2] electrically. This device was tested under commercial conditions in the vicinity of Albany.[3]

An improved model shown in Fig. 1 has been under test at this Station since late in 1932.[4] Heat is furnished by carefully spaced electric heating elements covered with aluminum fins to dissipate the

[1] Horsfall, James G. Zinc oxide as a seed and soil treatment for damping-off. *New York State Agr. Exp. Sta. Bul. No. 650. 1934.*

[2] The expression "to sterilize" is commonly applied to soil, but it is particularly inaccurate when applied here. To pasteurize is preferable, because not all the organisms in the soil are killed.

[3] Carney, Lawrence. Electric soil sterilization. *Agr. Eng.*, **13**: *95–96. 1932.*

[4] This model has been tested thru the courtesy of the manufacturers, The Consolidated Car Heating Co., Albany, N. Y.

Fig. 1.—The Electric Pasteurizer.

heat into the soil. This particular designs holds 1 cubic yard of soil, altho other sizes may be purchased or built locally. It is built of boiler plate insulated on the outside. It has a boiler plate lid that is lifted while loading and a similar bottom for dumping the soil. Better insulation on the top and bottom would help this model immensely. More recent models have an insulating blanket for a covering to reduce the loss of heat.

TESTING THE ELECTRIC PASTEURIZER

Tests of power consumption[5] indicate that this cubic yard outfit requires almost precisely 5 kilowatts of current per hour at 220 volts. Its operating cost can be determined from this by any particular user from the cost of his current.

The question of how long to run the machine in order to control damping-off could not be settled without knowing the temperatures necessary, and these were found to depend upon the length of time that the various temperatures were permitted to act. Investigation of this relation showed that relatively low temperatures acting for a long time would do the job without injuring the soil as high temperature steaming does.

In these tests the outfit was filled to capacity in the morning with ordinary soil at room temperature and of medium wetness. The soil was naturally contaminated with *Pythium ultimum,* the microorganism responsible for most of the damping-off in the Station greenhouses. *Rhizoctonia solani* and *Botrytis* sp. also occur in this soil, but they are unimportant damping-off pathogenes. A thermometer or thermograph inserted in the top about 10 inches deep and midway between the center heaters was read at intervals during the heating process, and the machine was turned off when the temperature reached the desired point. This was usually in the afternoon.

The temperature of the soil at the thermometer always rose 25° or 30°F after the current was turned off. During the heating process the temperature rose most rapidly at the bottom of the pasteurizer, where the heaters were closest together, and cooled off most rapidly there because of poor insulation. The next most rapid rise and fall of temperature was at the top. The temperature

[5] The Empire Gas and Electric Co. kindly supplied a meter for measuring the power.

rose and fell least rapidly in the center of the mass. In the early tests the temperature was permitted to rise to 160°F, later to 140°F, then to 120°F, and finally to 105°F, before turning off the current.

In all of the cases the destructive microbes were killed and no disease occurred when tomatoes or spinach were planted in the soil as indicator plants. In one test with spinach, for instance, 1,150 seeds were planted in each of two flats, one pasteurized, the other not. In the pasteurized soil 1,051 seedlings emerged as compared with 236 in the untreated soil, giving stands of 91.4 per cent and 20.5 per cent, respectively. Moreover, only 2.5 per cent of the seedlings damped-off in the pasteurized soil as compared with 49.1 per cent in the unpasteurized.

A large number of other tests gave similar data. One of these is illustrated on the front cover. In this test 79.6 per cent of the 1,150 spinach seeds planted in the pasteurized soil (A) came up as compared with 37.2 per cent in the untreated soil (B). The percentages of damping-off were 0.4 and 66.7, respectively. These and dozens of other tests all indicate that soil need not be heated higher than 105°F before the current is turned off, provided that the soil can be left in the pasteurizer overnight.

To heat a cubic yard of soil in this pasteurizer to 105°F at the thermometer midway between the upper heaters requires about 4 hours or less, consumes about 20 kilowatts of current costing 30 cents at the rates prevailing at the Experiment Station. Of course, the heating requires more time if the soil is colder or wetter at the start than that used in these experiments.

Electric pasteurizing not only kills the damping-off organisms in the soil, but it also kills nematodes and other troublesome animals, such as slugs and soil inhabiting insects. It also eliminates most weed seeds from the soil, altho clover seems to escape and purslane will survive occasionally. As a result, plants grown in pasteurized soil are more vigorous and healthy than those grown in unpasteurized soil. Fig. 2 shows this effect on two flats of transplanted tomatoes photographed alongside the cold frame where they were grown. The tomatoes in the unpasteurized soil on the right had a yellow or a bronze color and were too "hard" to start readily in the field.

Much more research needs to be done with this machine, but the facts in hand indicate that it is thoroly practical and that it merits a place in the damping-off control program in New York State.

FIG. 2.—ELECTRICALLY PASTEURIZED SOIL PRODUCES VIGOROUS PLANTS.

Tomato plants of equal age ready to be transplanted into the field. Those in pasteurized soil (A) are taller, greener, and more vigorous than those in unpasteurized soil (B). Plants in the unpasteurized soil are yellowed and bronzed, are small and scrawny, and have roots that are browned and more or less decayed. These plants will start off in the field more slowly than those in the pasteurized soil.

COMPARING ELECTRIC PASTEURIZATION WITH STEAMING

Steaming soil or "sterilizing" it at high temperatures even with electric heat is detrimental to it, as is well known. Steamed soil is darkened in color, plants sown in it immediately may be stunted or even killed, and the soil loses much of its water-holding capacity. Steamed soil is usually allowed to stand for a few days to regain its normal condition. This is an expensive storage period, and frequently the soil becomes recontaminated before it is used.

Pasteurizing soil is like pasteurizing milk; it destroys the pathogenic germs without impairing the good qualities. With the electric pasteurizer, soil can be heated *from the inside* at a large number of points, and can be kept at a relatively low temperature for a long time instead of at a high temperature for a short time as is the necessary practice with steam treatment.

Electric pasteurization will not be cheap, but the cost probably will compare favorably with that of steam. Growers interested in an inexpensive method of damping-off control, should use some of the chemical methods, such as that described in Bulletin No. 650 of this Station.

PRACTICAL USE OF THE ELECTRIC PASTEURIZER

It is worth while here to summarize the information that has been obtained on points that practical growers will need to know in using these devices. It is essential to remember that the pasteurizer acts like an old fashioned fireless cooker. The soil is heated to the desired temperature with electric heat. The current is turned off and the heat that is in the soil is allowed to act on it overnight. This method of using the pasteurizer is very economical of electricity, which is an expensive source of heat at best. Granted that the overnight, fireless cooker effect is necessary to save expense and to avoid injuring the soil, then temperature becomes the unknown variable. The minimum temperature required would vary from greenhouse to greenhouse. Of course, a blanket recommendation of 160°F for 4 hours would probably kill all the germs, but it might injure the soil somewhat and would cost more than necessary. It seems more logical, therefore, to recommend that the soil be held in the pasteurizer overnight and then to use the lowest possible temperature to be determined by the grower himself under the conditions of his own greenhouse.

Results obtained at this Station indicate that it would be safe with the 1-cubic-yard outfit to heat the soil at a point midway between the upper heaters to 105°F or higher before turning off the current. This should require between 3 and 4 hours. Local tests could use this as a starting point. Since soil in smaller models would lose heat more rapidly than that in larger models, it might be necessary to use a thermostat with them in order to take advantage of this low-temperature long-time effect.

Since electrically pasteurized soil may become reinfested with damping-off organisms, it is necessary, obviously, to handle it carefully. It should not be returned to dirty benches or handled with dirty tools. These should all be sterilized in a formaldehyde solution containing a quart of formaldehyde in 25 gallons of water, or by any other method that is equally effective.